Public Health 126: Introduction to Health Economics and Public Policy Problem Set 1: Solutions

UC Berkeley

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Please answer the following questions in a clear and concise manner.

1 Calculating marginal benefits

You, like the rest of Berkeley, have caught the cold. You have decided that you want to take medication to help end your ailment. Of course, each dosage that you take will give you varying benefit (i.e., "treatment"). The total benefits of the doses in dollars are given in Table 1. The market for cold medicine is perfectly competitive; that is, all suppliers produce a dosage for $2 each.

Table 1: The benefits of doses of cold medicine

Dose	Total benefit	Marginal benefit	Average benefit
1	10	10	10
2	20	10	10
3	27	7	9
4	32	5	8
5	36	4	7.2
6	39	3	6.5
7	41	2	5.86
8	42	1	5.25
9	42	0	4.67

a. Complete Table 1.

b. How many doses should you consume? Why?
Solution: You should consume 7 doses. First notice that, in a competitive market, price will equal marginal cost. Hence, price is $2. At 7 doses, marginal benefit equals price, the necessary condition for optimal consumption.

c. Calculate the elasticities of demand when you consume

i. 5 doses
Solution:

$$\epsilon = \frac{Q_1 - Q_0}{P_1 - P_0}\frac{P_0}{Q_0} = \frac{6-5}{3-4}\frac{4}{5} = \frac{-4}{5}$$

ii. 8 doses
Solution:

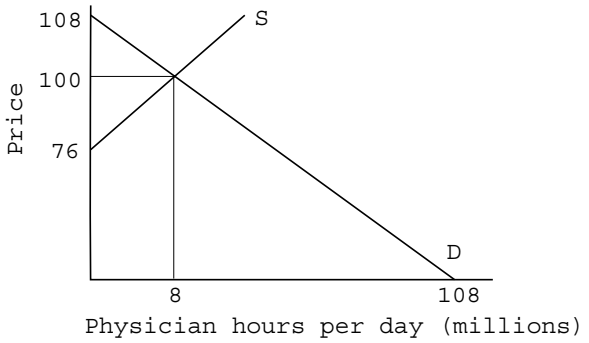
$$\epsilon = \frac{Q_1 - Q_0}{P_1 - P_0}\frac{P_0}{Q_0} = \frac{9-8}{0-1}\frac{1}{8} = \frac{-1}{8}$$

2 The supply and demand for physician services

The total supply of physician services is given by $P_S = 76 + 3H_S$, where P_S is the price that physicians receive and H_S is the total number of hours that physicians work per day in millions. Demand for physicians services is given by $P_D = 108 - H_D$, where P_D and H_D are the price that consumers pay and the number of hours of service consumed respectively.

a. What is the law of demand? Does it hold here?
Solution: The law of demand states that there is an inverse relationship between price and quantity demanded. The negative coefficient on quantity in the demand equation (i.e., -1) confirms that this condition holds.

b. Show graphically and calculate algebraically the equilibrium in this market. In *Health Policy Issues*, it is reported that there are about 800,000 physicians in America. How many hours does the average physician work per day?
Solution:



In equilibrium, $P_S = P_D = P$ and $H_S = H_D = H$, hence we can equate these two curves to solve for the equilibrium.

$$\begin{aligned} P &= 76 + 3H = 108 - H \\ 4H &= 32 \\ H &= 8 \end{aligned}$$

Since 8 million hours are worked per day, each physician must work an average of 10 hours per day.

It is important to understand the difference between *movements along* a curve and *shifts* of a curve. For each of the following cases, state whether there is movement along or a shift of the curve for both demand and supply.[1]

[1]In the solutions below, it is assumed that neither demand nor supply are perfectly inelastic or elastic. These assumptions are necessary in predicting the change in quantities and prices.

c. Americans put down their Big Macs and start going to the gym—they become healthier.
Solution: Healthier patients demand fewer service from physicians. The demand curve shifts inward and there is movement along the supply curve. Quantity and price will fall.

d. There is significant growth in incomes for all Americans.
Solution: Physicians services are presumed to be a normal good; hence, as income increases, demand will shift out. There will be movement along the supply curve. Quantity and price will increase.

e. Doctors prefer to spend more time with their families.
Solution: Physicians' wages will need to increase to lure them away from leisure time. Higher input prices shift the supply curve inward. There is movement along the demand curve. Quantity falls and price increases.

f. It becomes easier to enter medical school and become a certified physician.
Solution: The supply of physicians will increase, shifting the supply curve outward. There is movement along the demand curve, resulting in a lower price and higher quantity.

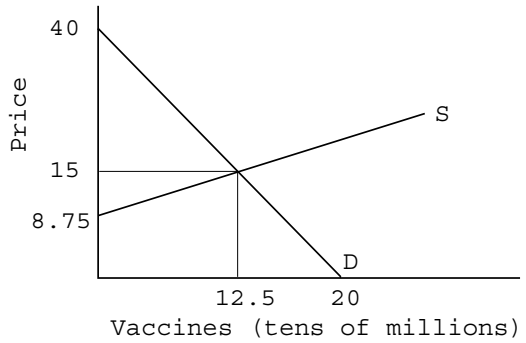
g. The cost of being treated in the emergency room increases.
Solution: Emergency room treatment is a substitute for visiting a physician. Presuming that the consumer faces some portion of the price increase of emergency room services, demand for physician services will shift outward. Movement along the supply curve yields a higher price and quantity.

h. The wage of nurses, who assist physicians, increases.
Solution: Nurses are an input to physician services. An increase in their wages will shift the supply curve inward. A higher price and lower quantity are found after a movement along the demand curve.

3 Externalities and subsidies

There is a market for influenza vaccines. Demand is given by $P_D = 40 - 2V_D$, where P_D is the price of the vaccine paid by consumers and V_D is the number of vaccines consumed divided by ten million. The supply of vaccines is given by $P_S = 8.75 + \frac{V_S}{2}$, with P_S and V_S being the price received by suppliers and the number of vaccines supplied divided by ten million.

a. Draw a supply-and-demand diagram depicting the equilibrium. Find the equilibrium algebraically.
Solution:



Equating supply and demand yields

$$\begin{aligned} P &= 40 - 2V = 8.75 + \frac{V}{2} \\ \frac{5V}{2} &= 31.25 \\ V &= 12.5 \\ P &= 15 \end{aligned}$$

As an aside, the NIH predicted that approximately 130 million flu vaccines would be available for the 2007–2008 flu season.

b. What is the elasticity of demand at the equilibrium? Of supply? Are producers or consumers more responsive to price at the equilibrium?
Solution: The elasticity of demand is

$$\begin{aligned} \epsilon &= \frac{V_1 - V_0}{P_1 - P_0}\frac{P_0}{V_0} = \frac{V_1 - V_0}{(40 - 2V_1) - (40 - 2V_0)}\frac{P_0}{V_0} = \frac{V_1 - V_0}{-2(V_1 - V_0)}\frac{P_0}{V_0} \\ &= \frac{-1}{2}\frac{15}{12.5} = -0.6 \end{aligned}$$

where the last line substitutes the values of P and V at the equilibrium. Following similar steps, the supply elasticity is $\eta = 2.4$. Since the elasticity of supply is bigger in absolute value compared to the elasticity of demand at the equilibrium, producers of the vaccine are more responsive to price than consumers. Indeed, demand is inelastic ($|\epsilon| < 1$), while supply is elastic ($\eta > 1$).

c. Define the term *externality* and discuss why the government may want to subsidize vaccinations.
Solution: An externality arises when an individual does not bear the full costs (a negative externality) or benefits (a positive externality) of his actions. Here, a vaccinated individual gets protection from the flu himself, but, because he can no longer transmit the flu, his vaccination reduces the probability that those around him will become infected. He is not compensated for the latter effect and thus he does not take this benefit to others into account when making his decision—he only accounts for the private value (i.e., the value to himself) of vaccination, not the social value (i.e., the value to himself and everyone else around him). While this is optimal from his perspective, it is not optimal for society. To align his benefits with the social benefits, the government could provide a subsidy to reduce the price of the vaccination.

d. Assume that the government gives producers a subsidy for each vaccine that they produce. What happens to the demand curve? To the supply curve? Does the equilibrium quantity go up or down? Does the price that consumers pay go up or down? By more or less than the amount of the subsidy?
Solution: Here, the supply curve will shift out because, for any given price, producers are willing to produce more in the presence of the subsidy. The demand curve does not shift. There is an increase in quantity, a lower price to consumers, and a higher price received by producers (because the subsidy is larger than the price reduction that consumers receive).

e. Now assume that the government gives a subsidy to each consumer that gets vaccinated. What happens to the demand curve? To the supply curve? Does the equilibrium quantity go up or down? Does the *net* price that consumers pay go up or down? By more or less than the amount of the subsidy?
Solution: This is the analogue to the previous question. Here, the demand curve shifts out and the supply curve does not shift. Net of the subsidy, consumers will pay a lower price and suppliers will receive a higher price, and quantity will increase. *Note that the same equilibrium—same prices to producers and consumers and the same quantity—arises whether the subsidy is given to producers or consumers. You can think about this graphically or algebraically, but be sure that you understand why this is the case.*

f. Instead suppose that the government wants producers to make more vaccines and implements a *price floor*: consumers must pay at least \$20 for the vaccine. Is there an equilibrium in this market? How many vaccines are produced? How many are consumed?
Solution: With a price floor of \$20, suppliers would produce 22.5 units of vaccines, as given by the supply curve. The demand curve reveals that consumers would only purchase 10 units of vaccines at this price. A surplus of 12.5 units is created and only 10 units are consumed. Since the quantity demanded does not equal the quantity supplied, there is no equilibrium. The vaccination rate is less than in the free market equilibrium (12.5 units) or the equilibrium with a subsidy (more than 12.5 units).

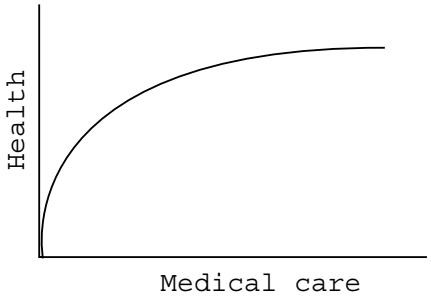
g. Lastly, the government wants more people to become vaccinated, so it implements a *price ceiling*: consumers will pay at most \$10 for the vaccine. Is there an equilibrium in this market? How many vaccines are produced? How many are consumed? Who will get vaccinated?
Solution: Consumers demand 15 units of the vaccine, but producers are only willing to supply 2.5 units. The result is a shortage and again there is no equilibrium. Only 2.5 units of vaccine are supplied—the lowest of all the policy options considered.

4 The production of health

In a simplified model, there are three inputs for producing health (H): nutrition (N), environmental factors (E), and medical care (M). Production is given by the Cobb-Douglas form:

$$H = N^{\frac{1}{2}} E^{\frac{1}{4}} M^{\frac{1}{4}}$$

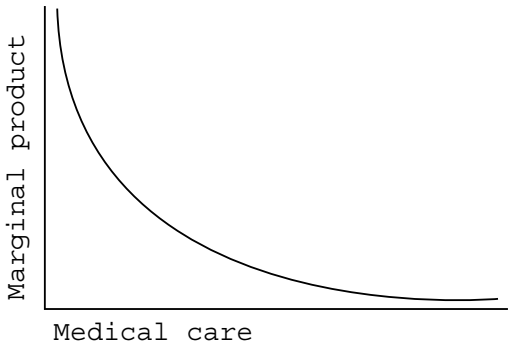
a. Draw a sketch of the relationship between health and medical care, holding nutrition and environmental factors constant.
Solution:



b. Find the equation for the marginal productivity curve of each input.
Solution: The marginal productivity curve is found by taking the derivative of the production function with respect to the variable of interest, holding the others constant.

$$\begin{aligned}
\frac{\partial H}{\partial N} &= \left[\frac{1}{2}N^{\left(\frac{1}{2}-1\right)}\right]E^{\frac{1}{4}}M^{\frac{1}{4}} = \left[\frac{1}{2}N^{\frac{-1}{2}}\right]E^{\frac{1}{4}}M^{\frac{1}{4}} \\
\frac{\partial H}{\partial E} &= \left[\frac{1}{4}E^{\left(\frac{1}{4}-1\right)}\right]N^{\frac{1}{2}}M^{\frac{1}{4}} = \left[\frac{1}{4}E^{\frac{-3}{4}}\right]N^{\frac{1}{2}}M^{\frac{1}{4}} \\
\frac{\partial H}{\partial M} &= \left[\frac{1}{4}M^{\left(\frac{1}{4}-1\right)}\right]N^{\frac{1}{2}}E^{\frac{1}{4}} = \left[\frac{1}{4}M^{\frac{-3}{4}}\right]N^{\frac{1}{2}}E^{\frac{1}{4}}
\end{aligned}$$

c. Draw a sketch of the marginal benefit curve for medical care.
Solution:



d. If you want to maximize health, should you focus on just one of these factors? Why?
Solution: No, you must use all three variables to create health effectively. You should invest in each factor until marginal productivity (i.e., benefit) is equal to the price of the factor (i.e., marginal cost). These investments will produce health in the most efficient manner.

5 The demand for health insurance

Each individual has a utility curve over total wealth given by $U = \sqrt{W}$, where W is wealth. Suppose that each individual has a 90% chance of being healthy and a 10% chance of being sick. If he is healthy, he gets all his wealth—\$90,000. If he becomes sick, he only has \$10,000 remaining after medical expenditures.

a. Does marginal utility increase or decrease as wealth goes up? Why?
Solution: This curve shows that utility increases with wealth, but at a declining rate. That is, marginal utility decreases as wealth increases. Of most relevance here, this reflects risk aversion; some moderate wealth is preferable to the "gamble" of being either very wealthy or very poor. Risk aversion implies that you would rather have some level of income for sure rather than have uncertainty about what your wealth will be.

b. What is his utility if he is healthy? If he is sick?
Solution:

$$\begin{aligned}
U_H &= \sqrt{90,000} = 300 \\
U_S &= \sqrt{10,000} = 100
\end{aligned}$$

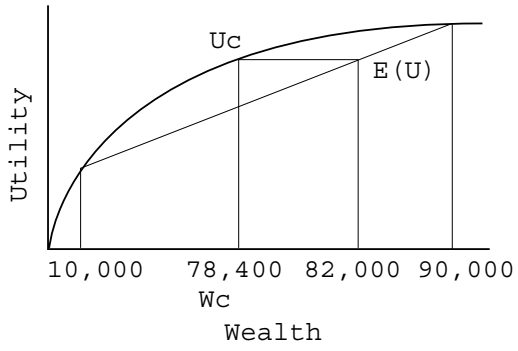
c. What is his *expected utility*?
Solution:

$$\begin{aligned}\mathbb{E}(U) &= \Pr(\text{healthy}) \times U_H + \Pr(\text{sick}) \times U_S \\ &= 0.9 \times 300 + 0.1 \times 100 = 280\end{aligned}$$

d. How much wealth would he need to be indifferent between receiving this amount for sure and accepting the risk of varying wealth depending on whether he is healthy or sick (i.e., what wealth achieves the same level of utility as the expected utility over the states of sick and healthy)?
Solution: Define U_C as the utility of wealth that an individual receives for certain that leaves him just as well off (i.e., he is "indifferent") as taking the gamble of being healthy or sick. Let W_C be the wealth associated with this utility.

$$\begin{aligned}U_C &= \mathbb{E}(U) \qquad \text{(This is by definition)} \\ W_C &= U_C^2 = [\mathbb{E}(U)]^2 = 280^2 = \$78,400\end{aligned}$$

A graph may help:



Now he has the option of buying health insurance.

e. What is the most that he would be willing to pay for insurance?
Solution: Since he is just as well off with \$78,400 for sure as he is taking the gamble, he would pay up to $\$90,000 - \$78,400 = \$11,600$ for insurance.

f. What is the *actuarially fair* price of insurance in this problem?
Solution: The actuarially fair price is calculated by subtracting his expected wealth from his healthy income. This gives you the expected loss from being sick.

$$\begin{aligned}\mathbb{E}(W) &= \Pr(\text{healthy}) \times W_H + \Pr(\text{sick}) \times W_S \\ &= 0.9 \times \$90,000 + 0.1 \times \$10,000 = \$82,000 \\ &\quad \$90,000 - \$82,000 = \$8,000\end{aligned}$$

Note that the actuarially fair premium (\$8,000) is less than the most that he would be willing to pay for insurance (\$11,600). This is what we expect for a risk averse individual.

g. Should we expect actuarially fair insurance prices? Why?
Solution: No, we do not. Insurance companies incorporate a *loading charge* into the price of insurance. This covers administrative and marketing costs, plus for-profit firms must generate a reasonable return for their investors. These charges are added on to the actuarially fair price.

6 Short response

The answers to the following three questions **in total** may not exceed two handwritten or (preferably) two, double-spaced typed pages.

a. What factors have driven the increase in health care costs over the last three decades? What can be done?
Solution: The most important factor driving increases in per-capita health care spending in the late twentieth century is increased technology. The state of many medical procedures is called "halfway technology," which treats the disease once it has occurred. This is very expensive. As we gain additional understanding of these conditions, we will move to preventative medicine—"high technology." This will reduce the cost of maintaining current health levels, but, invariably, new "halfway" technologies will continue to emerge over the foreseeable future and thus prices will continue to rise.

Additionally, the poor (via Medicaid), the old (via Medicare), and the middle and upper classes (via tax-preferred, employer-provided health insurance) have received expanded insurance coverage. This coverage has weakened the link between the actual price of medical care and the price that consumers pay. Hence, consumers are demanding more treatment than is efficient, which further increases prices. Managed care helped to constrain cost increases and deregulation and antitrust enforcement have opened the medical sector to increased competition. These supply-side reductions in price have been no match for the costs of new technologies and increased demand and moral hazard on the part of consumers, however.

b. Why are hospitals in the United States largely non-profit, while physicians are for-profit?
Solution: There are three reasons why hospitals are non-profit, while physicians are for-profit. Historically, hospitals were charitable institutions where doctors donated their time. Hospitals were small and, since technology was minimal, not necessary for physicians to perform their duties. As a result of this path dependence, non-profit hospitals became dominant. Secondly, patients hold more trust in doctors than in hospitals, all else equal. Doctors, after all, are required to take an oath to "do no harm." By becoming non-profit, hospitals can attempt to gain trust and credibility in the eyes of the public. Lastly, physicians have encouraged hospitals to remain non-profit because they can have a bigger role in their governance under this system. Rather than pleasing shareholders, they could please the hospital's board.

c. Are we spending too much on health care? Explain.
Solution: To answer this question, we must define "too much." One definition would dismiss the question, stating flatly that, if consumers are willing to pay for it, then the price cannot be too high. A more sophisticated analysis, however, would suggest that "too much" refers to market efficiency or, more importantly, a lack thereof. A reformulated question would be, "are we consuming an inefficient level of health care?"

On this question, the answer is likely affirmative, though the inefficiencies in the health care system are likely decreasing. Inefficiencies arise because consumers are insulated from the actual price of treatment. This moral hazard encourages patients to demand too much

health care. The great expansions in insurance coverage (as discussed in part 6a) over the past fifty years have only furthered these inefficiencies. On the supply side, however, health care providers face new incentives to be efficient. Managed care employed cost containment measures that reduced the incentive for providers to encourage overtreatment. But, so long as patients still face moral hazard, the level of health care consumption will remain inefficiently high.